PUBLIC SECTOR INVESTMENT EFFICIENCY IN DEVELOPING COUNTRIES

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Abstract. There are numerous examples where public investment has been grossly mismanaged and where corruption has overwhelmed the entire process (unfinished roads, highways leading to nowhere, incomplete or unusable bridges and power generation projects). This article aims at reviewing the existing literature on the potential impact of such public investment inefficiencies on productivity and output, in theoretical models and empirical exercises. We conclude that despite recent progress in assessing and incorporating such inefficiencies in economic analysis, the composition of public capital, its interlinkages with other factors of production and with structural economic conditions should remain a key area of future research.

Unlike with private investors, there is no plausible behavioral model in which every dollar that the public sector spends as "investment" creates economically valuable "capital." While this simple analytic point is obvious, it has so far been uniformly ignored in the empirical literature on economic growth.
Lant Pritchett (2000)

I. INTRODUCTION

There is a broad consensus that a scaling-up of investment in developing countries, particularly in infrastructure, is critical to achieve sustained growth. Particularly in many low-income countries, deficiencies in infrastructure may sometimes reduce productivity by at least as much as structural factors, such as bureaucracy, corruption and lack of financing. Recent studies by the World Bank and the IMF suggest that the growth impact of higher infrastructure spending in low-income countries is

potentially substantial – if low-income countries halved their infrastructure gaps, reaching the level of middle income countries, annual growth rates would increase by about 2 percentage points.

In many developing and low-income countries, however, the link between public capital spending and capital stock accumulation, and hence growth, is weakened by evidence of low efficiency of public investment. The notion that public investment spending leads to equivalent capital accumulation rests on the assumption that public investment is inherently productive. This assumption is particularly problematic in many developing countries, as a high degree of inefficiency, waste, or corruption often distorts the impact of public spending on capital accumulation, leaving a trail of poorly executed and ineffective projects.

While the literature suggests that a scaling-up of investment in developing countries is vital, the link with outcomes depends critically on the quality and efficiency of public investment. This highlights the importance of going beyond discussions of spending levels and addressing issues of the broad institutional framework underpinning the provision of investment. As accurately described by Caselli (2005) “less-accountable poor-country governments are likely to be disproportionately less efficient (relative to the private sector) than rich country ones. Hence, there are good reasons to expect the government to play an especially detrimental role in the productivity of investment in poor countries.” This translates into variability in the market value of the capital stock.

In terms of theory, this would imply adjusting our standard models of economic growth. A clear way to achieve this would require incorporating in the capital accumulation process, a parameter to capture public investment inefficiency, and consequently modifying the stock of public capital in the aggregate production function. Recognizing that both the investment and the stock of public capital are compromised by government inefficiencies is likely to alter predictions of standard models. In terms of empirics, being able to estimate the difference between investment cost and capital value is of first-order empirical importance especially for developing countries for whom public investment is the primary source of investment. In practical terms, assessing the quality of project selection, appraisal, implementation, and evaluation in a country can help identify the specific weaknesses that contribute to poor outcomes and guide appropriate institutional and technical remedies that could correct such failures.

This entry is structured as follows: In Section II we provide a selected literature review focusing on two distinct generations of analytical work on the productivity of public capital. In Section III, we turn our attention to estimation issues, particularly related to efficiency of public capital, by challenging some of the main assumptions made in the basic growth models. Subsequently, we consider and discuss in some detail different measures of inefficiencies found in the literature, and conclude the Section with some examples of empirical applications using such measures. In Section IV we present recent work that focuses on general equilibrium models that incorporate public investment inefficiencies and analyze in detail their effects not only on aggregate output but also several sectors of the economy. Finally, Section V concludes with discussion on future research.

II. TWO GENERATIONS OF RESEARCH ON PUBLIC CAPITAL

Substantial research has been devoted to measuring the productivity of public capital. In response to the massive public sector investment booms in many developing countries in the 1970s, Little and Mirrlees (1974) provided a systematic and practical cost-benefit methodology to assess public investment decisions. In a follow-up article, Little and Mirrlees (1990) expanded on their methodology and demonstrated some of the benefits of their approach which inspired an extensive literature that lasted for decades and is the starting point of most project evaluation work today. Partly using some of the work by Little and Mirrlees, the first generation of research that started in the late 1990s typically found that public capital can offer very large productivity gains, notwithstanding the wide range of theoretical and empirical frameworks employed. Aschauer (1989, 1998) in a series of papers estimated the output elasticity of public capital in the range of 0.3–0.4 and was the first to assign public capital an important role in explaining the fall in US productivity growth observed in the 1970s and 1980s. The literature that followed largely confirmed Aschauer's findings. Munnell (1990a, 1992) estimated the impact of public capital on growth at 0.31–0.39 at the national level though in Munnell (1990b) found a lower impact of 0.15 at the state level. In a similar setting, Lynde and Richmond (1993) found that the services of public capital are an important part of the production process, and that about 40 percent of the slowdown in the growth rate of labor productivity is explained by a fall in the public capital-labor ratio. Several other papers reached similar conclusions; see Sturm et al. (1998), for a comprehensive review of this generation of studies.

Over time these first-generation estimates were questioned on the grounds of numerous methodological and econometric limitations (Gramlich, 1994). Issues ranking high on the list of potential problems included reverse causation from productivity to public capital (public capital affects productivity, and in turn is affected by productivity) and spurious correlation due to non-stationarity (time-varying properties of the public capital series). This controversy sparked a new generation of research, which compared to the results surveyed by Sturm, Kuper and de Haan (1998) estimated substantially lower effects of public capital on growth; see Romp and de Haan (2007) for an extensive review. Moreover, while attempting to address the aforementioned estimation problems, the research unveiled substantial heterogeneity among countries, regions, and sectors. This is not surprising, as the effects of new investment spending depend on the quantity and quality of the capital stock in place. In general, the larger the stock and the better its quality, the lower will be the impact of every additional unit of capital added to this stock (the marginal productivity of capital). The network character of public capital, notably of infrastructure, also results in non-linearities in the impact of public capital on growth. It is these non-linearities which explain some of the above heterogeneity. Thus, the effect of new capital will crucially depend on the extent to which investment spending is targeted to alleviate bottlenecks in the existing network. Further studies suggest that the effect of public investment spending on growth may also depend on institutional and policy factors (Tanzi and Davoodi, 2000; Sawyer, 2010).

Bom and Litghart (2010) summarized the estimates of the output elasticity of public capital available from the literature by means of a meta-regression analysis. They find that the unconditional average output elasticity of public capital centers around 0.15 but suggest substantial heterogeneity across

countries. They also show that studies that impose constant returns to scale restrictions across private labor and capital (Mas et al., 1993; Otto and Voss, 1994; and Kavanagh, 1997), control for the business cycle (Aschauer, 1989; Hulten and Schwab, 1991; and Sturm and De Haan, 1995), and incorporate some measure of education (Garcia-Milà and Mc Guire, 1992) find larger output elasticities of public capital, whereas studies that include energy prices (Tatom, 1991) tend to find lower estimates.[1] The conditional output elasticity of public capital in the regression equation which captures typical study characteristics is estimated at 0.17, which is not that far from its unconditional (without capturing the study characteristics) value of 0.15. These values imply a marginal productivity of public capital for the United States in the range of 29-33 percent in 2001.

Given data limitations and the difficulty in constructing public capital stock series for developing countries, the early empirical literature on these countries often looked directly at the impact of public investment on economic growth (Devarajan, Swaroop and Zou, 1996). Arslanalp et al. (2010) was among the first to estimate a production function using the public capital stock as an explanatory variable, for a sample of 48 developed and developing countries. The effect of public capital on growth is estimated to be stronger for developed countries in the short-term (0.13), while it is stronger for developing countries in the long-term (0.26). In some countries, they find that the positive impact of public capital on output is partially or wholly offset if the initial ratio of the capital stock to GDP is high. Their results also show that in developing countries certain types of constraints (financing or the ability to absorb) can limit the growth benefits of higher capital stock and, unlike in advanced countries, the benefits of new investment tend to accrue more gradually.

III. RECENT WORK SHEDS MORE LIGHT ON THE WAY THAT PUBLIC INVESTMENT

Efficiency might decline during investment booms. Warner (2014) looks at big long-lasting drives in public capital spending in developing economies, and concludes that only a weak positive association exists between investment spending and growth, and that too only in the same year. According to the author public investment drives have tended to be financed by borrowing and have been plagued by incentive problems and interest-group-infested investment choices at the time investment projects were chosen. In addition to the inefficiency issues public investment booms are also faced by severe absorptive capacity issues. Presbitero (2016) reports evidence in a panel of a large number of developing economies that investment and infrastructure projects are less likely to be successful when they are undertaken during periods of higher than average public investment. This evidence is consistent with the presence of supply bottlenecks and poor project selection and with the importance of sound policies and institutions for the selection and management of public investment projects.

One of the most basic dynamic equations in macroeconomics is that of the accumulation of capital which (under some conditions) is given by:

[1] Imposing constant returns to scale across private inputs implies increasing returns to scale across all inputs if the factor share of public capital is positive. This could produce upward bias in the estimates if the true model is characterized by decreasing returns to scale across private inputs.

$$G'_{it} = G'_{it-1} - \delta_{it} * G'_{it-1} + q_i * I_{it-1} \quad (1)$$

where for each country *i*, G'_t is the stock of public capital at time *t*, and I_{t-1} is public investment spending at time *t-1*. δ_{it} is country *i*'s time-varying rate of depreciation of the capital stock. Equation (1) indicates that the stock of physical capital in any period is equal to the fraction of total investment converted into capital in addition to the existing undepreciated capital stock.

As most prominently noted by Pritchett (2000)—a criticism that goes to the heart of this topic—the behavioral model embedded in this universally used equation and hence in all of the existing empirical literature as summarized previously, assumes full public-sector efficiency (i.e. $q_i = 1$) even when there are no empirical or theoretical grounds for making such an extreme assumption. To the contrary; it is widely believed that in many countries only a fraction of the actual accounting cost of investment passes into the value of capital. Yet this obvious point is routinely ignored and cross-national estimates of physical capital still continue to be based on the assumption of full efficiency of public investment. As such, the assumption of full public capital efficiency cannot be the last act in drawing meaningful conclusions on the impact of public capital or investment on growth.

One does not have to look far to see the difference the public investment efficiency can make. The quality of infrastructure component of *The Global Competitiveness Index* taken from *World Economic Forum* (2016) shows that for advanced countries the quality of infrastructure measured on the 1–7 scale is clustered at the high end with very low variation, suggesting that efficiency differences might not play a pivotal role among these countries. However, for low- and middle-income countries the median scores are almost two points lower than advanced countries with much larger variation in the scores. Thus, to truly understand the impact of investment or capital efficiency on economic outcomes, it is most useful to explore this issue for the developing world.

While the WEF index captures *the quality of capital*, for a researcher it is more informative to understand *the quality of the process* that turns investment into public capital. To our knowledge the first such more comprehensive Public Investment Management Index or PIMI is provided by Dabla-Norris et al. (2012) for the four stages of public investment management—appraisal, selection, implementation, and evaluation—covering 71 developing countries (40 low-income and 31 middle-income countries).[2] Table (1) suggests that, on average in the PIMI sample, only about half of public investment efforts translate into actual productive public capital. Even when accounting for possible biases that may exaggerate this finding, inefficiencies in public investment remain massive and are well recognized by both academics and policymakers alike.

[2] To construct PIMI data were compiled from a large number of sources including from World Bank Public Investment Management case studies, Public Expenditure and Financial Accountability assessment reports, the Budget Institutions database, World Bank Public Expenditure Reviews, World Bank Country Procurement Assessment Reviews, World Bank Country Financial Accountability Assessments, and country websites.

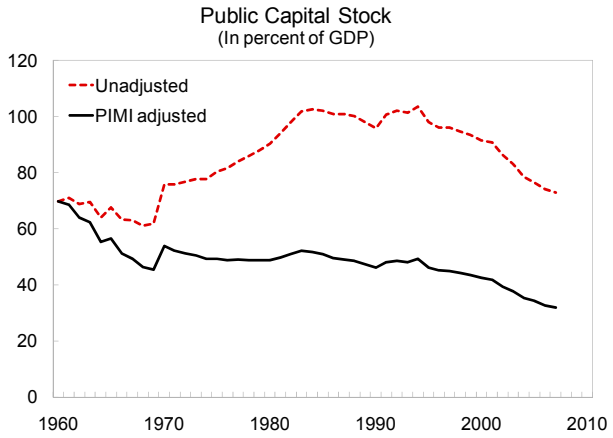
Table 1. Public Investment Management Index (PIMI) by Income Group

	PIMI	Appraisal	Selection	Implementation	Evaluation
Low Income (40)	0.47	0.21	0.28	0.30	0.20
	(0.26)	*(0.13)*	*(0.11)*	*(0.10)*	*(0.10)*
Middle Income (31)	0.57	0.21	0.30	0.28	0.22
	(0.25)	*(0.09)*	*(0.11)*	*(0.07)*	*(0.07)*
All countries (71)	0.51	0.21	0.29	0.29	0.21
	(0.26)	*(0.11)*	*(0.11)*	*(0.09)*	*(0.09)*

Sources: Dabla-Norris et al. (2011) and authors' calculations. Standard deviations are in parentheses.

This masks significant heterogeneity between countries and, even more notably, between each of the sub-indices. Further, the pair-wise rank correlations between PIMI and other similar indices such as the Budget Institution index constructed by Dabla-Norris et al. (2010), Kaufman and Kraay (2008) governance indicators (including Government Effectiveness, the average of the Governance Indicators, and the Control of Corruption index) and the World Bank's (2009) Country Policy and Institutional Assessment (CPIA) index are positive though not overly high, ranging from 0.3 to 0.6. This indicates that the PIMI can carry information on the quality of public investment not fully captured by other more general institutional and governance indices and can thus be considered as a complement to, and not a substitute for, these more general indices.

Gupta et al. (2014) are the first to directly adjust public investment for efficiency. Their methodology to accumulate the capital stock series by equation (1) is similar to that used by Collier, Hoeffler and Pattillo (2001), Kamps (2006) and Arslanalp et al. (2010). For the crucial efficiency parameter q_i they use normalized PIMI as well as its four subcomponents. The text chart showing the general results of capital accumulation exercise indicates a significant gap between the traditional and efficiency-adjusted public capital stock in the order of 40 percent of GDP in the recent years available. It is also remarkable that throughout the sample period, and contrary to the unadjusted stock, efficiency-adjusted capital has substantially declined—a trend led mostly by low-income countries—indicating that high-quality public investment would be associated with a high marginal product.

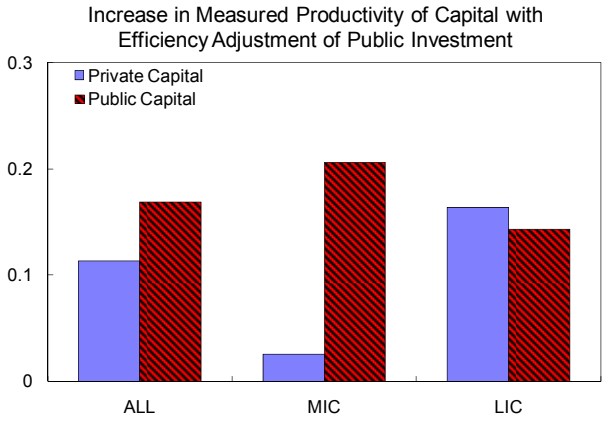


Armed with the new efficiency-adjusted

capital stocks Gupta et al. (2014) proceed to estimate an otherwise standard unconstrained Cobb-Douglas production function:[3]

$$Y_{it} = A_0 S_{it}^{\alpha} K_{it}^{\beta} G_{it}^{\gamma} e^{\lambda_t + \varepsilon_{it}} \quad (2)$$

where skill-adjusted labor S_t is computed according to $S_{it} = L_{it} * e^{\varphi(h)}$, where L_{it} is raw labor and h is the average years of schooling in the population aged 15 years and older. $\varphi(h)$ is a stepwise linear function adjusting the average years of schooling by estimates for returns on education. The econometric results indicate that adjusting public capital for public investment efficiency better explains the evolution of relationship between public capital and growth. The efficiency adjustment reduces the estimated share of public capital in the production function to around 0.15 that is statistically significant for both low- and middle-income countries. More importantly, it leads to a corresponding increase in the shares of private capital, especially for LICs. As a result of efficiency-adjustment and corresponding changes in estimated production function coefficients, the marginal productivity of both private and public capital increases (see text chart). The increase in private capital productivity is higher in low-income countries (LIC), whereas the increase in public capital productivity is higher in middle-income countries (MIC).



PIMI components can be omitted one-by-one, from the accumulated stock of public capital. This exercise indicates that the importance of investment stages for productivity of public capital varies with income levels. Project implementation (which comprises competitive and open bidding and internal audit) is the most critical component of the investment process. This result, which holds on aggregate, is driven mostly by low-income countries in the sample, for whom project selection (that is related to medium-term framework) assumes secondary importance. For the middle-income countries, project appraisal (which comprises transparency of appraisal standards) and projection evaluation (which comprises external audits) are relatively more important. While for all countries for which PIMI is available, implementation stands out as the stage with higher relative productivity, the results for sub-samples are mixed. This indicates that new public investment must be accompanied by strengthening of specific bottlenecks in investment processes to enhance the productivity of public capital.

[3] Aggregate data on output, investment and raw labor are taken from PWT version 6.2, public investment shares to accumulate capital stocks are taken from WEO databases, and the average years of schooling come from the Barro and Lee (2010) database on educational attainment.

IV. TOWARDS THE THIRD GENERATION OF RESEARCH

A number of theoretical applications have directly modelled public sector investment efficiency as in equation (1) in the DSGE framework to allow for a richer set of interactions, including the presence of a zero lower bound on nominal interest rates. Berg et al. (2013) are among the first to model declining investment efficiency in the stock of public capital capturing capacity constraints. Especially for resource rich countries, this can support a more gradual public investment strategy for windfall savings that could initially be saved in an external fund.

More importantly, Berg at al. (2015) identify and clearly explain a key steady-state result characterized by the invariance of growth with respect to investment efficiency: the impact of additional investment on the growth rate of output does not depend on the level of the time-invariant efficiency parameter *q*. This is easy to see in a two-equation system consisting of capital accumulation equation (1) and a Cobb-Douglas production function such as (2) with only public capital as an input:

$$Y_t = A_t G_t^{\gamma}. \text{ (3)}$$

Equation (1) implies that, in a steady state:

$$K = \frac{qI}{\delta}. \text{ (4)}$$

The rate of return of a marginal unit of investment can then be expressed as follows:

$$\frac{dY}{dI} = \frac{dY}{dK} * \frac{dK}{dI} = \gamma \frac{Y}{I} \text{ (5)}$$

Equation (5) implies that the impact of a marginal change in investment on the growth rate of output (which is a product of the marginal productivity of capital and the capital stock per unit of investment), is simply equal to the public capital share γ in the production function and does not depend on the level of investment efficiency *q*. The general intuition to this invariance lies in the law of diminishing marginal productivity: since the time-invariant efficiency *q* permanently scales down the capital stock, diminishing returns imply higher marginal productivity. These two effects work in the opposite direction and with Cobb-Douglas exactly offset each other. This implies that inefficiency, per se, would not lead to lower growth and should not be considered as a reason to not invest.

However, it must be noted that the impact of public investment and its efficiency on output and growth can be more complex than implied by the aforementioned two-equation system. At least four key reasons can be brought out that can support growth effects of investment efficiency. First, the Berg et al. (2015) is a long-run *steady-state result* that does not preclude that changes in investment efficiency affect *transitional growth* towards the steady state, in a manner similar to the saving rate in exogenous growth models. Second, as is also acknowledged by the authors, patterns of complementarities between the production factors matter: if public and private capital are

complements, public investment in low-efficiency countries could still have an impact on the growth rate of output through higher marginal productivity of private capital. Third, intuitively investment inefficiency can have an impact on growth (even at steady state) through scale effects, if the level of effective capital determines the level of technology at the aggregate level, creating positive externalities similar to the pioneer endogenous growth models of Romer (1986) and Lucas (1988). Fourth, the impact of investment and efficiency on growth can depend on the *structural conditions* of the economy, including cost of financing, the fiscal space, and the level of debt.

For example, Buffie et al. (2012) show that *productive* public and private capital are complements. However, if structural conditions are weak, including low public investment efficiency and collection rates, instead of crowding-in a surge in public investment can crowd-out private investment and could lead to unsustainable public debt. Model simulations by IMF (2014) show similar results for developing economies characterized by *structural conditions* that usually exhibit less slack, less accommodative monetary policies, and importantly lower public investment efficiency. In these economies, a public investment shock leads to substantially lower long-term output effects compared to advanced countries, and a higher public debt to GDP ratio that in turn can impinge on growth.

Finally, interactions between public and private capital pose an important policy question on the use of public-private partnerships (PPPs): if accounting for high public sector investment inefficiencies also leads to higher marginal productivity of private capital, can more widespread use of PPPs be associated with higher growth, especially in LICs? While research here is still scarce, it can prove to be a promising field. Buffie et al. (2016) document that, even if costlier, PPPs produce higher quality capital at shorter times compared to public sector own investment. Their general equilibrium simulations suggest that PPPs can have a social return 5–8 percentage points higher than own public investment.

The work on the efficiency of public investment has highlighted several limitations and would benefit from research across the following dimensions. First, the PIMI is available only for one period 2007-2010 and is thus time-invariant. While it encompasses cross-sectional variation, it is not able to capture changes that have incurred to investment processes over time. Second, the determination of depreciation rates of public capital stock that vary across time and countries as well as the level of the initial public capital stock, deserve further investigation to reduce measurement errors. Third, the empirical literature is yet rather silent on whether public capital is complementary to, or a substitute for, other production factors, including wealth of natural resources that is highlighted by Caselli (2005) as one of the factors that could bring the estimated marginal productivities of capital across countries closer together. Fourth, in an open-economy growth model with perfect capital mobility convergence would happen instantly as a fully integrated global economy ensures that differences in rates of return on capital are eliminated across countries. To explain why we do not observe this requires consideration of the possible frictions in international capital markets that slow down or eliminate convergence altogether. Obstfeld and Rogoff (1996) present an open-economy growth model that demonstrates in a very tenable and intuitive way the ability of market imperfections to yield convergence dynamics in an integrated

global economy. Whether lack of efficient public capital can provide an explanation of why capital does not flow to less developed countries, is a promising research avenue (see, e.g. Lowe, Papageorgiou and Perez Sebastian). Finally, investigation into the productivity of public capital would benefit from a wider exposure to different methodologies. Direct estimation of the investment efficiency parameters in a DSGE model as done by Berg et al. (2013, 2015) is a useful alternative if reliable information is otherwise lacking.

V. CONCLUSIONS

Public investment in bridges, roads and ports is truly essential in low-income countries which suffer from massive infrastructure gaps. It is considered one of the most important drivers of growth and a primary component of the development strategies of governments in the developing world. Significantly boosting investment in physical infrastructure to achieve sustained growth rests on the high returns to investment in capital-scarce environments, and the pressing deficiencies in these areas. However, inefficiencies in project appraisal, selection, implementation, and evaluation, lead to devastating losses in public capital accumulation and output. The history of public investment booms is filled with disheartening stories about “roads to nowhere” and “white elephants” especially in poor countries where public goods are in dire need.

This article suggests that considerable progress has been made by economists in better measuring, and more appropriately, incorporating public investment inefficiencies in economic models. In addition, our understanding of the drivers of these inefficiencies, such as poor incentive systems, inadequate capacity to appraise and implement projects, and absorptive capacity, has improved. Nonetheless more needs to be done in this important area of economics. As better data become available, including at the firm and sectoral level, economists should improve existing indices of public investment inefficiencies. This is resource-intensive work that requires careful collaboration with governments and researchers. But without the necessary and high quality data, assessment of inefficiency will not be possible. At the same time, country authorities must pay particular attention in improving their processes of project selection, appraisal, implementation and evaluation. This is a very attainable goal that encouragingly has started to become a priority in most economies of the developing world.

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